Materials Science Work at NASA Ames Research Center

Ames Research Center

Presentation to:
Aranui High School,
Christchurch,
New Zealand

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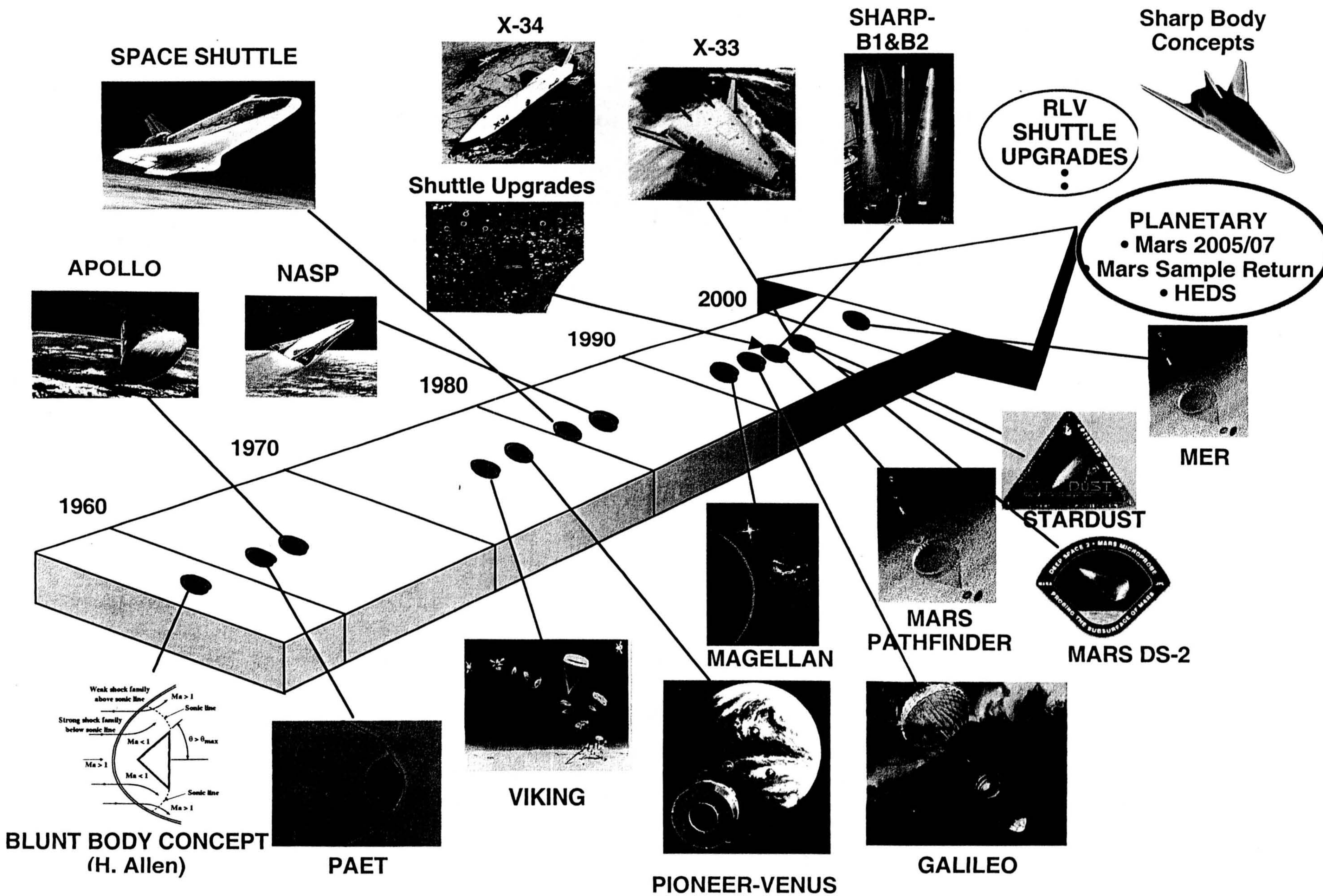
Outline

- NASA Ames Research Center
  - TPS Development, including testing
  - Materials for the Shuttle
  - Ablators
  - Coatings
  - Integrated Vehicle Health Management
  - Sharp leading edges
- More fun at work
  - Using the latest technologies
  - Playing with blowtorches
- What you should learn in high school and university to help you later
- Summary

NASA Entry Vehicles and Missions Supported by Ames



TPS Development

- TPS Material Development requires :
  - Material properties:
    - Generally low density
    - Refractory
    - Impact Resistance
    - Low Catalycity
    - High Emissivity
  - Modeling of behavior
    - Defining operating environment
    - Quantifying response to thermal and structural loads

TPS Development (cont'd)

- Testing
  - Laboratory-based
  - Creating conditions as close to flight as possible
    - Atmosphere (gas enthalpy)
    - Pressure
    - Heat Flux
  - Arc Jet can create an environment as close as possible to flight
  - Flight Testing
- NASA-Ames is capable of handling every stage of TPS development from conception, material properties investigations, and modeling, to fabrication, testing and end product delivery

Ames-Developed Thermal Protection Materials Adopted to Date on Shuttle

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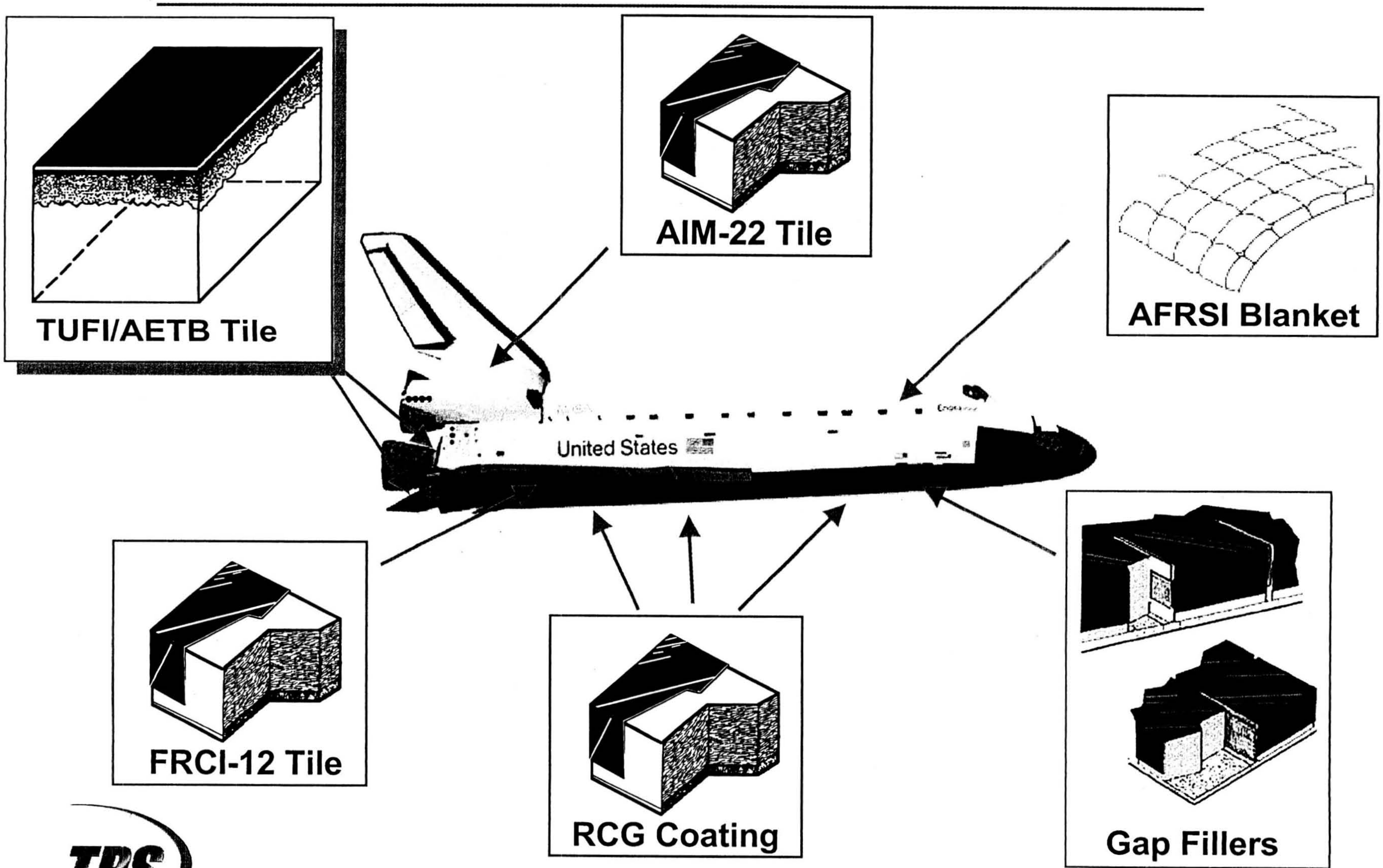

TPS

Typical Arc Jet Test Leg

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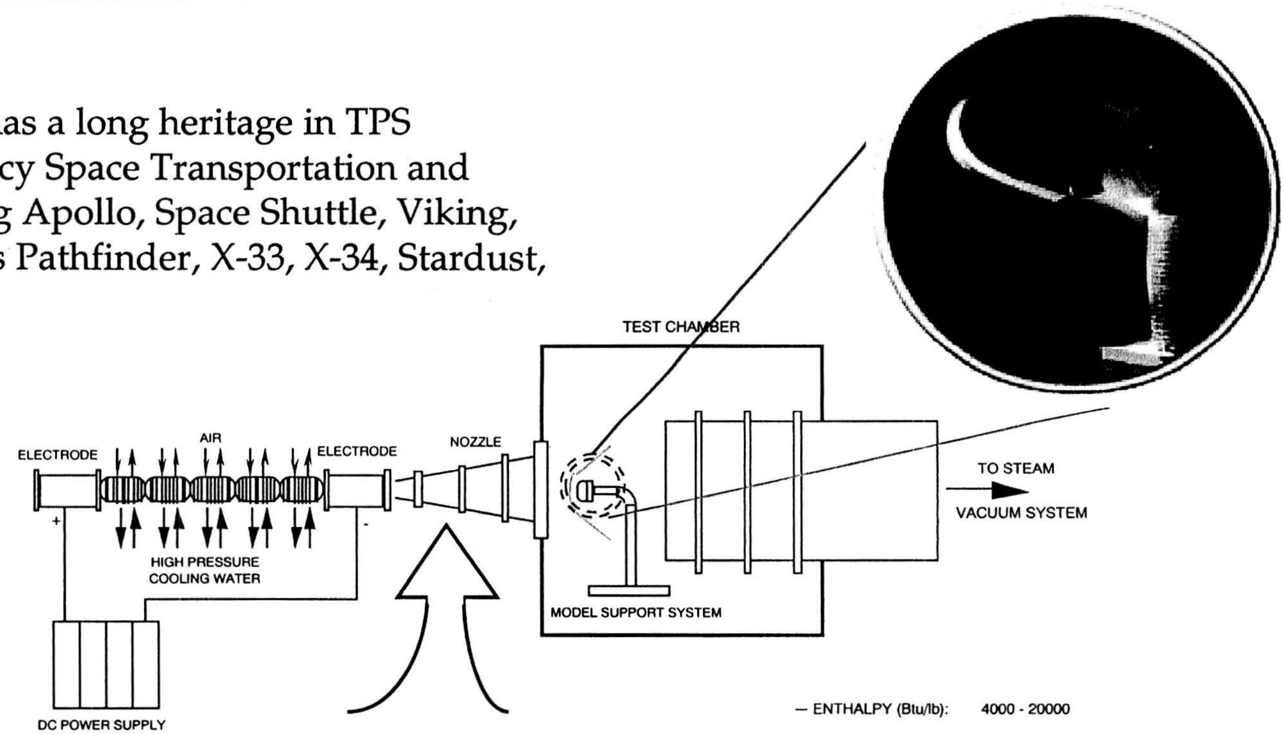
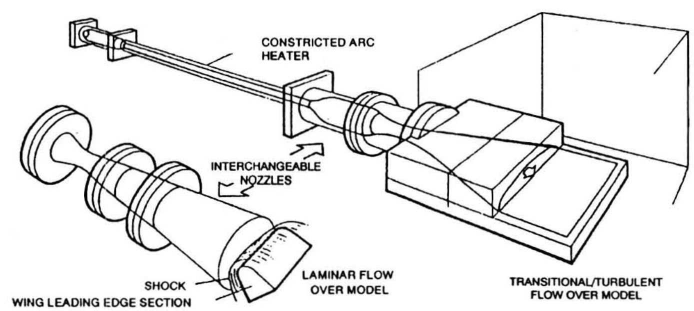
- The Ames Arc Jet Complex has a long heritage in TPS development for every Agency Space Transportation and Planetary program, including Apollo, Space Shuttle, Viking, Pioneer-Venus, Galileo, Mars Pathfinder, X-33, X-34, Stardust, SHARP-B1, and SHARP-B2.

- Presently on the critical path for X-37, Shuttle Upgrades, SHARP-L1, Generation 2 & 3 RLVs, Mars Landers '03 and '05 and Mars Sample Return Earth Return Vehicle

- The Arc Jet Complex is currently operating at extremely high production rates, averaging ~400 tests per year.





- ENTHALPY (Btu/lb): 4000 - 20000
- STAGNATION PRESSURE (atm):
  - FLAT-FACE MODEL 0.005 - 1.2
  - WEDGE MODEL 0.0001 - 0.15
- HEATING RATES (Btu/ft^2-sec):
  - FLAT-FACE MODEL 20 - 660
  - WEDGE MODEL 0.5 - 45
- SAMPLE SIZE (ft):
  - FLAT-FACE MODEL Up to 1.5
  - WEDGE MODEL Up to 2.5 × 2.5

TPS

Ames' Light Weight Ceramic Ablator Family
Ease of Manufacturing and Performance

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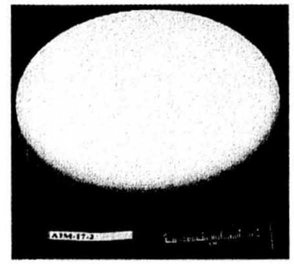
- SIRCA
  - Silicone Impregnated Refractory Ceramic Ablator
  - For medium heat fluxes
  - Made by infiltrating silicone resin into a silica-based tile
- PICA
  - Phenolic Impregnated Carbon Ablator
  - For high heat fluxes Phenolic resin infiltrated into carbon fiber preform
- APPLICATIONS
  - SIRCA: Mars/Pathfinder, X-34, Mars Exploration Rover, Mars Exploration Rover (A & B)
  - PICA: Stardust

SIRCA

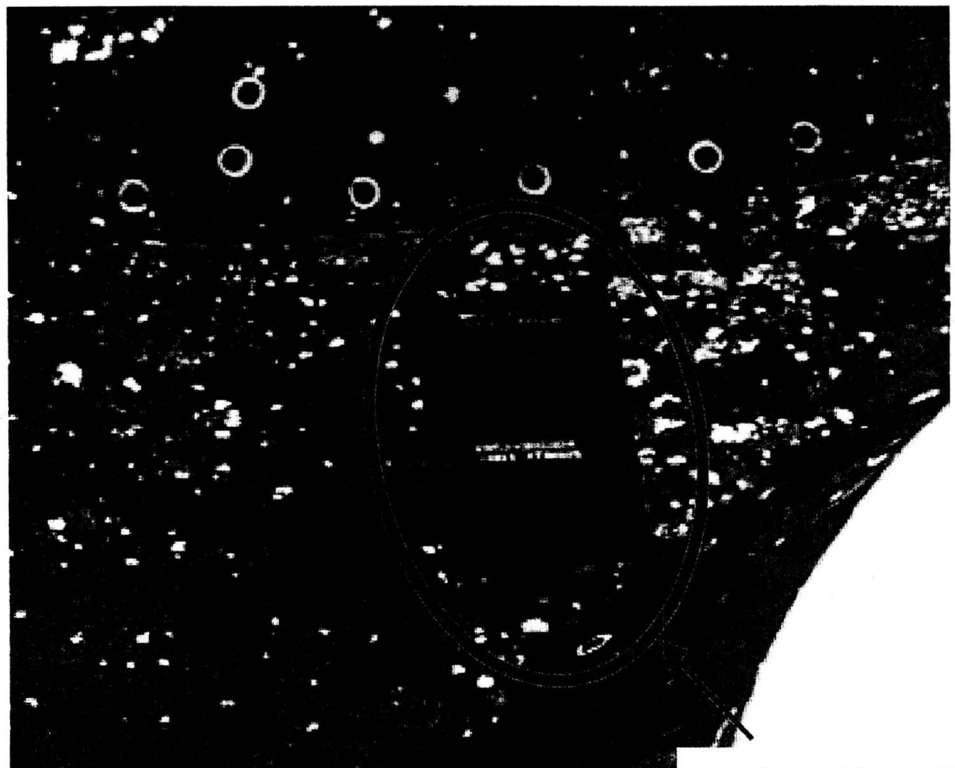


PICA

(Shuttle - low heat flux)

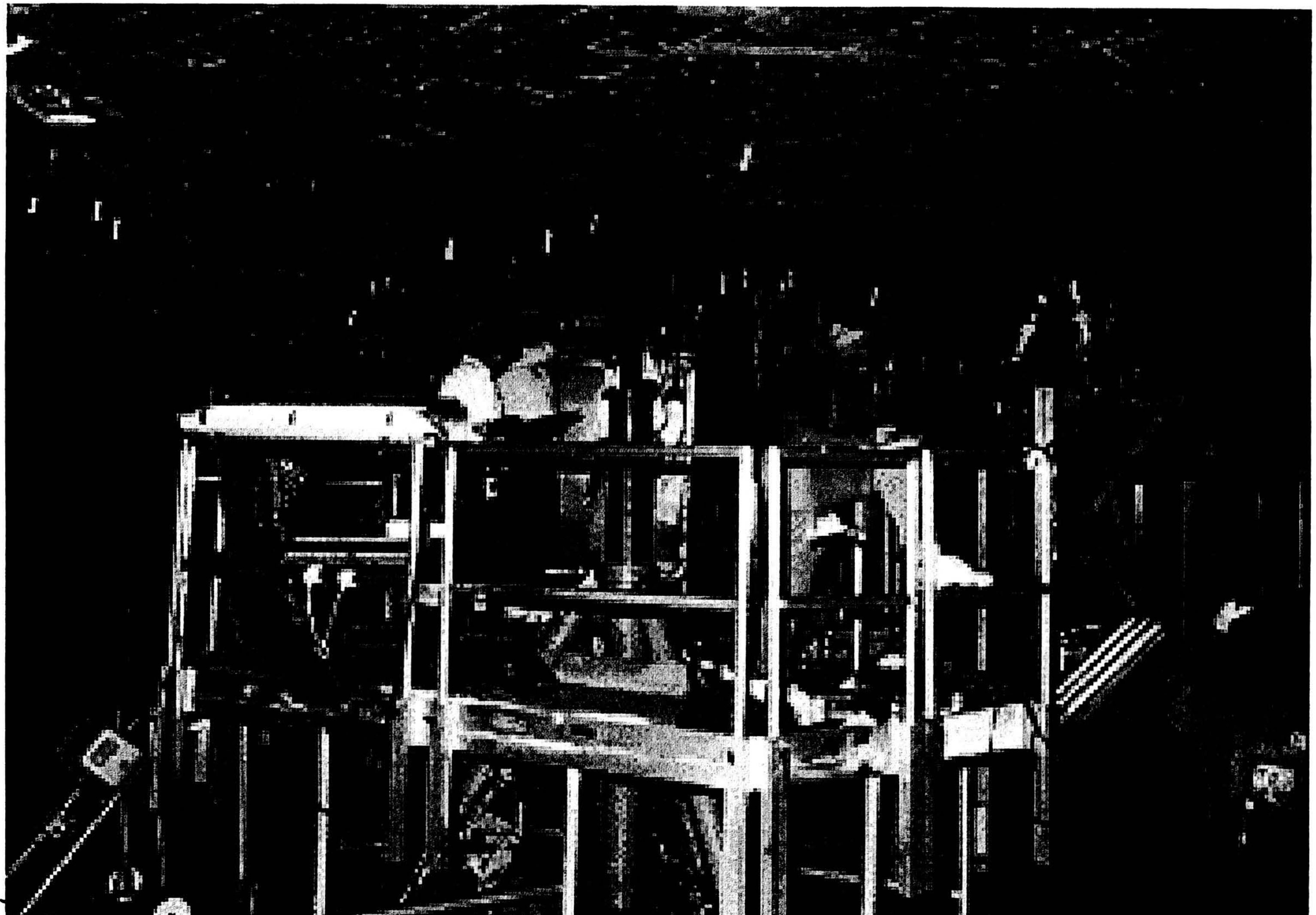
TPS

Shuttle Flight Testing of LI-900/RCG vs AETB-8/TUFI in Base Heatshield



TUFI/AETB-8 Tiles Undamaged After Three Flights

Health Monitoring: Shuttle TPS Inspection & Maintenance



Futuristic TPS Inspection Process

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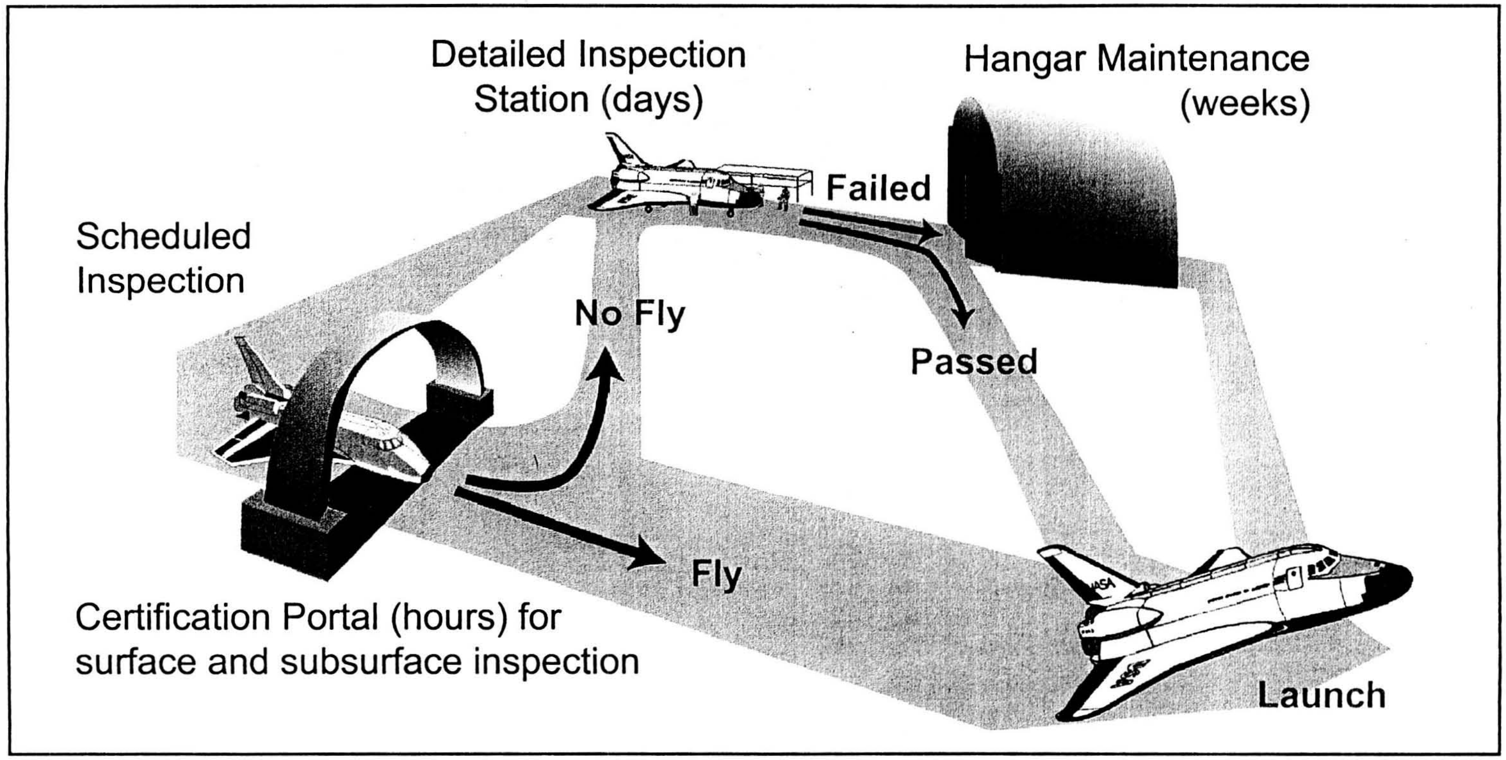

- The portal inspects the TPS as the vehicle passes.
  - Scan the exterior surface for damage.
  - Query the status of subsurface health sensors.
- Alternatively: automated scanning heads or small robots can perform the inspection.

Sharp Leading Edges Provide Increased Safety and Performance

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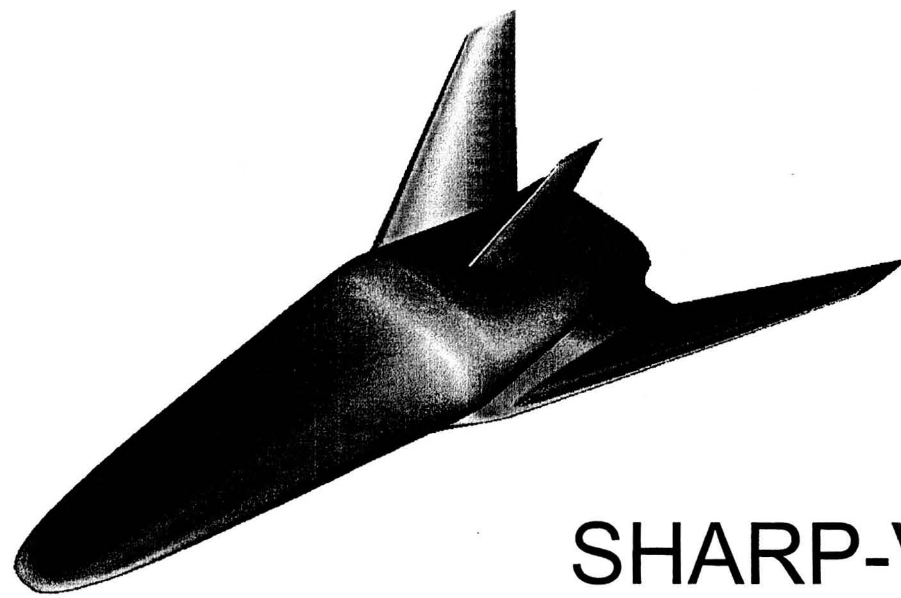
- Reduce propulsion requirements by decreasing drag
- Increase maneuverability
- Increase time during ascent for safe abort to ground
- Increase out-of-orbit cross range which enhances safety by increasing the number of potential landing sites



SHARP-V5

ISS Ground Track vs. Cross Range

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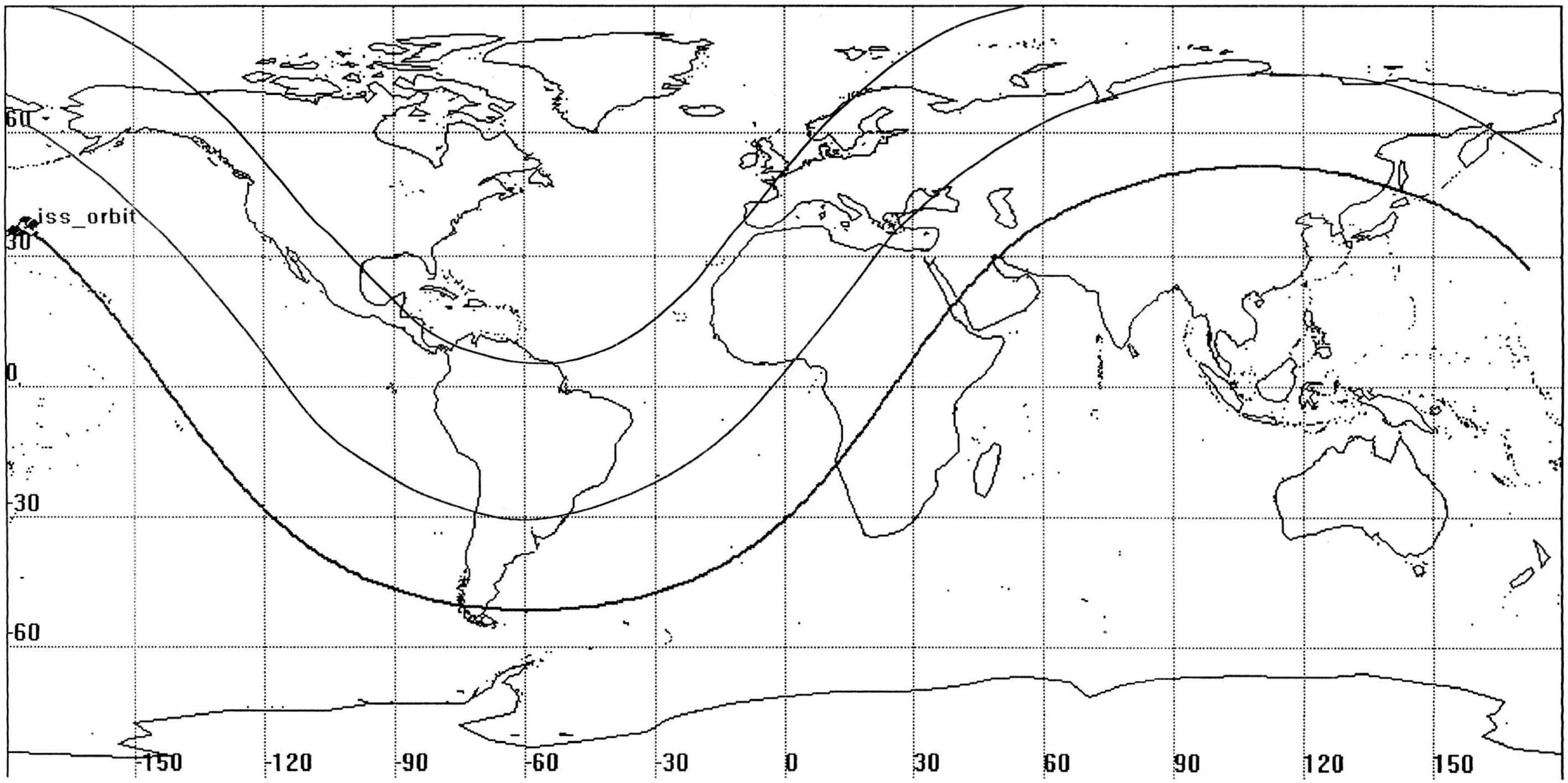
— International Space Station Ground Track

— Blunt Range Max Cross-Range 1360 nautical miles

— Sharp Body Max Cross-Range 3500 nautical miles



Missions Like SHARP-B2 Provide a Method to Evaluate Materials in a True Hypersonic Reentry Environments

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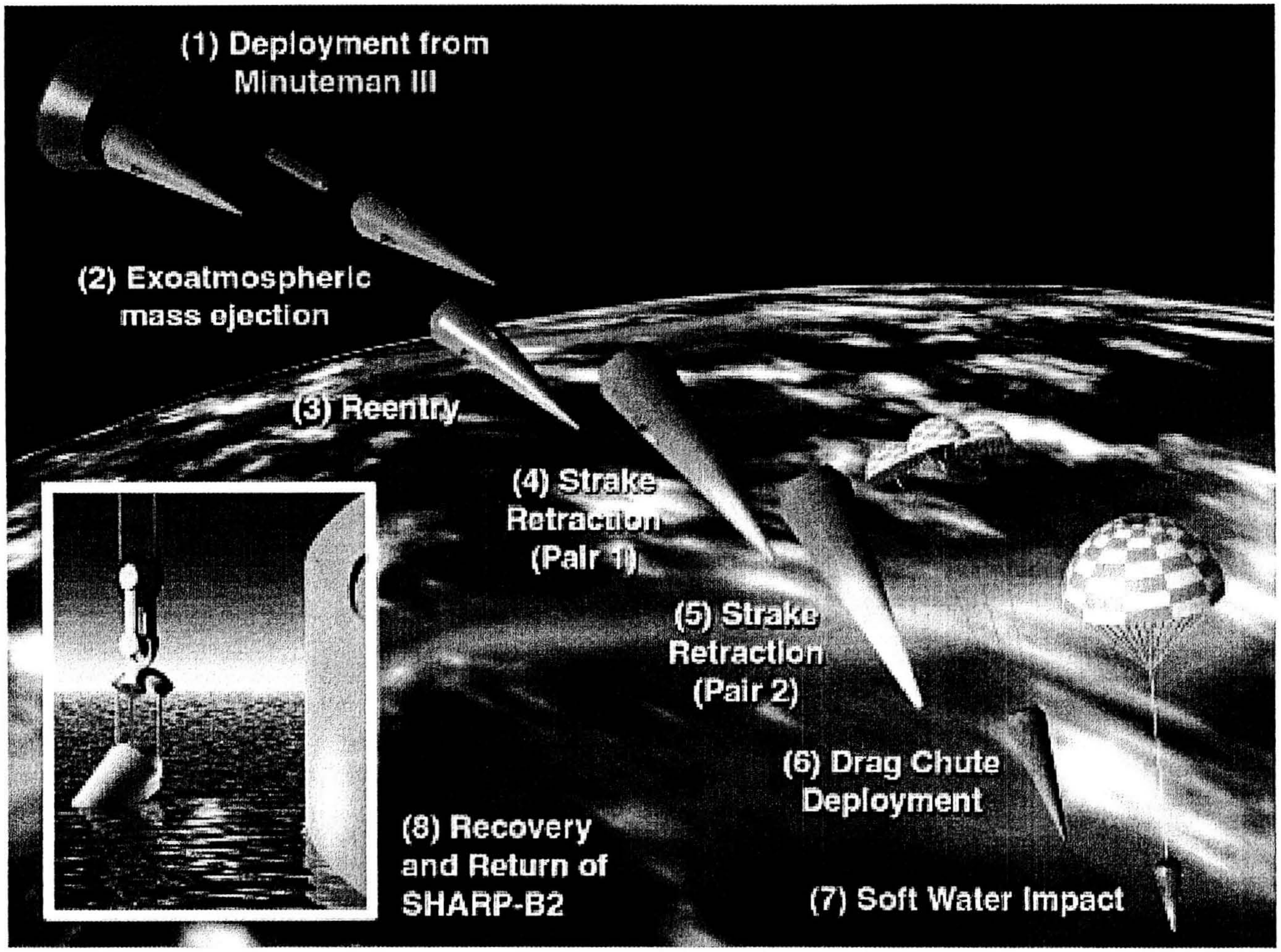

TPS

Large Processing Defects Are Observed

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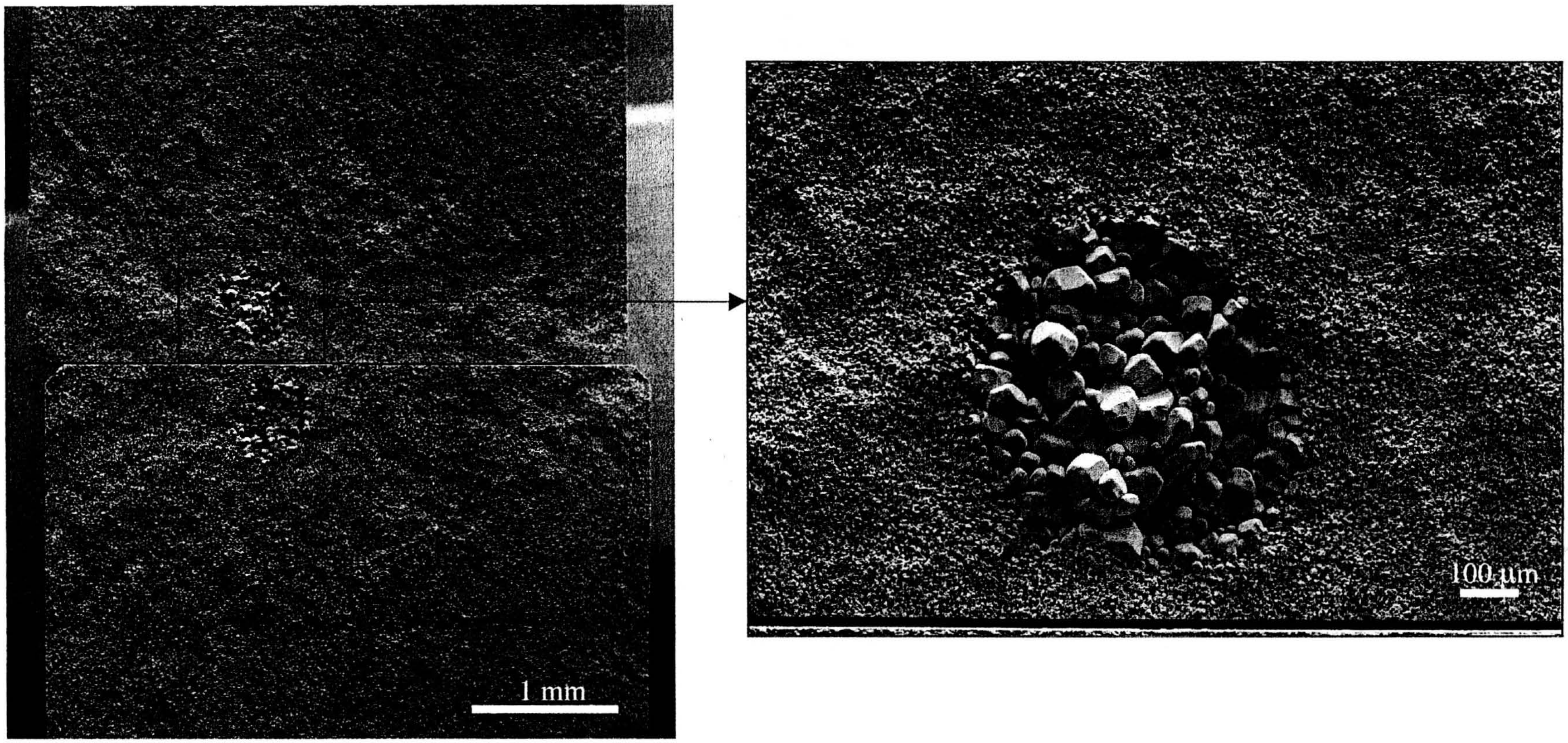
HfB$_2$/SiC Flexural Bar: σ = 75 MPa, T = 1200°C



- Large grain HfB$_2$ agglomerates present in microstructure due to incomplete mixing.

Source: Southern Research Institute

Where we are going: Mission Pull & Timeline for TPS contributions to NASA programs

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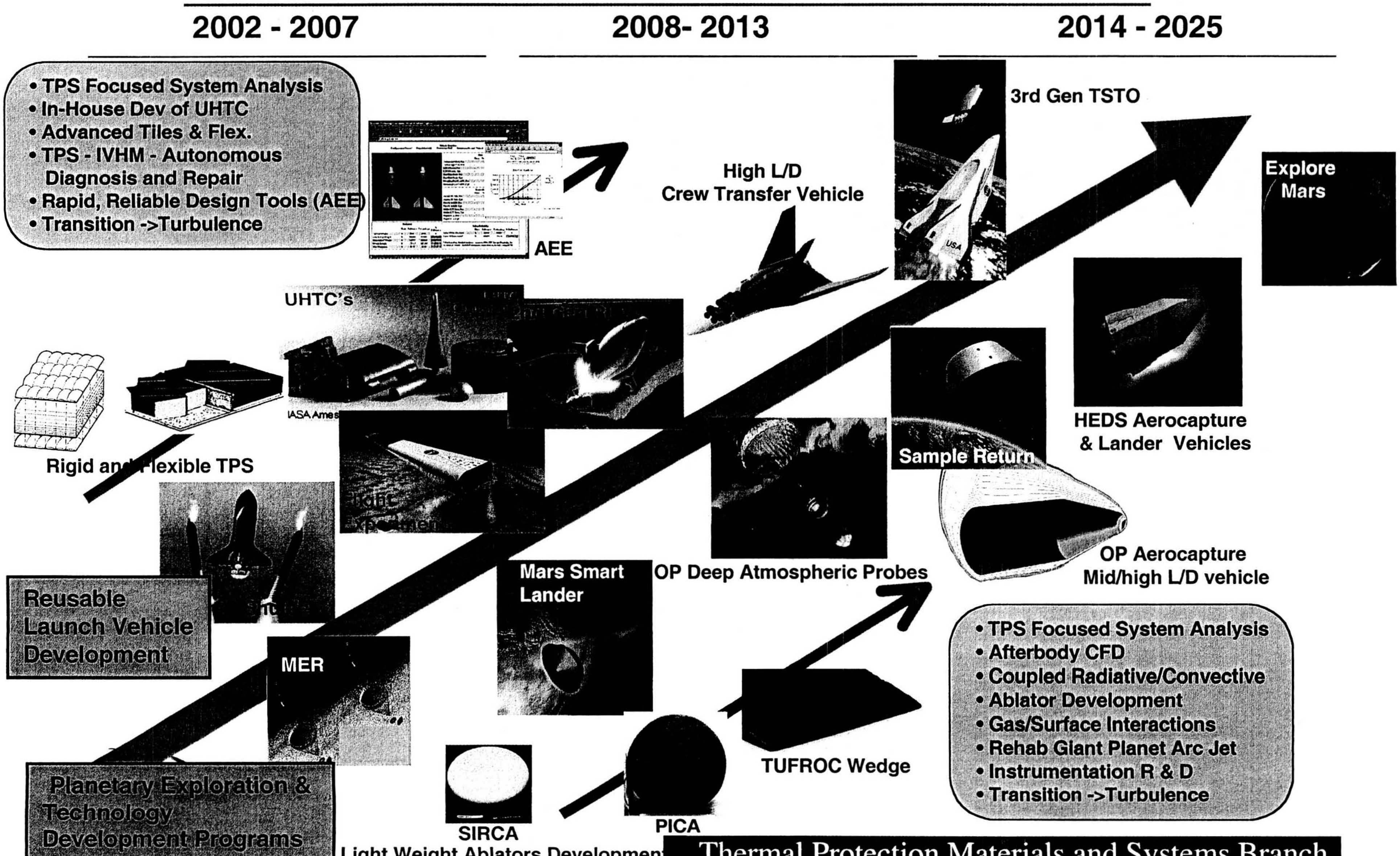

Thermal Protection Materials and Systems Branch

Summary of NASA Ames Materials Science work

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- Selection of thermal protection materials is based on environment and use (heat flux, temperature, reuse requirements, density)
- Materials with very high temperature capabilities will allow for sharp leading edges and improved vehicle performance and safety
- NASA Ames has a long heritage in the development of Thermal Protection Systems, and continues to fulfill NASA's missions through ongoing research and development
  - This is an exciting field in which to work

TPS

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Microstructure of Shuttle Tile (LI-900), Uncoated

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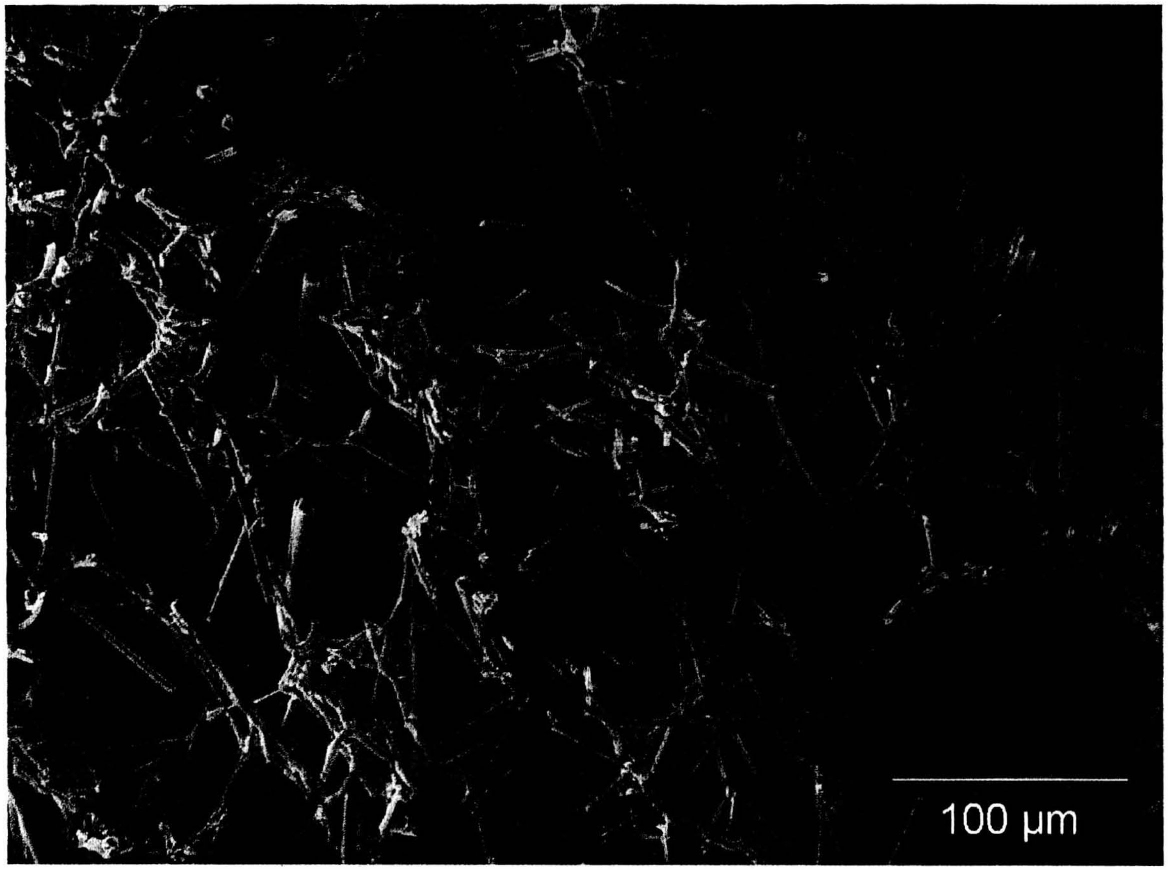

Sally Ride Science Camp

July, 2003, Intermediate School girls
Stanford University, Stanford, California

Fun with a Blowtorch

Informal non-scientific anonymous survey

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- Taken in April, 2003 at the Thermal Protection Materials and Systems Branch of NASA Ames
- Interviewed seven recent graduates (graduated within the last two years):
  - 4 women, 3 men
  - 6 Universities
  - 1 with 2 Bachelor's Degrees
  - 2 with Master's Degrees (one has also worked as an instructor at a state college)
  - 4 with PhD's
  - All now working in Research Scientist capacity, some as Project Managers, Lab Managers
- Asked them the following questions:
  - What are you glad you learned in college?
  - What do you wish you had learned/done/is there anything you regret not doing?
  - What advice would you give to college students?
- The following information represents their responses.
  - Supported by my many years of experience.

People skills

- Do
  - Learn how to work in groups
    - In real life, you are not alone; personality compatability/clashes directly affect the performance of everyone in the team, AND the project results
    - In the work environment you need to know how to explain things in simple terms and to put yourself in someone else's shoes
  - Take advice from a Project Manager
    - Interacting with people is the MOST important
    - The technical aspect is pretty small - what makes a project go well is coordinating, motivating, having people work together
      - If at all possible take a class or two in team-building or "dealing with difficult people"

Involvement in school

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- Do:
  - Use the school resources
  - Take advantage of career days
  - As much as you can to take the initiative to work with teachers and professors
    - Most people do not
  - Ask questions if in doubt - a lot of times people do not do this, as they do not wish to embarrass themselves, but do not be shy - when you ask, the rest of the group will start asking. Not clarifying at the outset makes confusion set in!
  - Take extensive notes on experiments; you may have to remake the samples one day, and so you need to know how

Involvement in school (cont'd)

- Do:
  - Be willing to learn new things; try, regardless of what others are doing
    - Employers look for people with the "spark in the eye", who are "fired up" about what they do, and are willing to take a different approach
  - Learn presentation skills on:
    - Yourself, your project
      - A presentation can determine whether you secure a job, or if something is funded

Do not!

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- Throw out your notes
- Throw out/sell your textbooks
- Assume you will not work in a specific place - you may become interested in that exact thing

School is unique

- Do
  - Have fun in school, study hard, but do the best you can to take advantage of the right opportunities to enjoy outings. You will miss it. Life is fun, but not in the same way.
  - Try and become involved in school life. The experience is unrivaled and can be quite enriching.
    - Take advantage of university-abroad programs

Summary

- You may never know where you may end up!